



## **‘Engaging in an argumentative discourse’- narratives from biology classrooms**

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### **Abstract:**

The present paper delves into the classroom dynamics of Biology classrooms taking into account teaching learning processes associated with some of the ethical issues in Biological Sciences. Argumentation and debate appear to be the major transactional approaches adopted by teachers for dealing with these issues. The classroom discourses emanating from teacher student conversations have been analysed on four planes, viz., ethical, social context, interactional context and personal agency of the teacher. Toulmin’s method of argument analysis has been used in order to analyse the level of arguments of both teachers and their students. The findings reveal significant differences on all the four planes at K-12 and Undergraduate levels and, have implications for building upon teachers’ pedagogical content knowledge (PCK) with respect to ethical issues.

**Keywords:** Science Teaching, Scientific Argumentation, Pedagogy, Ethical Issues, PCK

### **Introduction**

Science education can no more be taken from a unidimensional perspective rather has to take into account the discursive and multi-dimensional character. Taking cue from the history of science where multiple perspectives have acquired their own place, similarly in a science class room the views of different learners should be regarded well and add to the explanation offered to a given scientific phenomenon. However, the present state of science education in the country is deplorable owing to the insufficiency of teaching-learning methods and education in the same regard, lack of adequate resources and depleted interest levels in science teaching. These can be taken as some of the reasons for declining number of students opting for sciences at higher secondary and undergraduate level. The students are usually not able to identify themselves with the discipline and hence lose interest in the subject. In order to regain the interest in sciences, the necessary reforms need to be introduced both at the curricular level and at the practice level (i.e., pedagogy). The curriculum needs to be made more learner friendly as well as learner-centric by relating it with the daily-life experiences and providing scope for adding on to the present knowledge structure. The class rooms need to be more participatory rather than didactic to ensure the sharing and building of scientific understanding. The present study takes a peep into some of the biology classrooms and the kind of conversations taking place there. An attempt was made to purposely choose those classrooms where actual discussions and dialogues took place between the teacher and the learners and even amongst the learners. Such class rooms, however rare, became the focus of the present study and basis for analysis of class room dynamics. Ethical issues within biological sciences have been chosen as the topic under consideration for the analysis of classroom discourse.

Therefore, the present paper aims toward identifying and analysing the scientific arguments generated both by the teacher and students in the classroom over some of the ethical issues related to Biological Sciences.

## Science teaching as an Argumentative Practice

### *Meaning of 'Argument'*

The present study derives its theoretical basis from the method of scientific argumentation and its role in transcending students' understanding and learning beyond the class room and course content. Argumentation in general refers to making claims with adequate reasoning and based in an evidential background to support the claim made (Carr, 1999; Toulmin, 1958). Argumentation can also be defined as a skill in solving problems which often requires an active use of argumentation in order to reach a conclusion as well as formulation of ideas and beliefs (Kuhn, 1991). Scientific Argumentation has been used as a valuable approach for gauging students' understanding, their conceptual as well as epistemic notions about any subject (Duschl, Ellenbogen, & Erduran, 1999; Kelly, Druker, & Chen, 1998; Kuhn, 1992). Even scientific argumentation has been strongly advocated as a pedagogy for sciences (Newton, Driver and Osborne, 1999). Student arguments are also greatly affected by social factors (Richmond & Striley, 1996) and assumed understanding (Kelly, Druker, & Chen, 1998). Often the science curriculum is structured around facts and theories giving little attention to reason and argumentation in a scientific context (Osborne, 2010). Studies have proved that scientific curricula and modes of assessment focussing factual recall have declined the students' interest in sciences (Osborne, Simon, and Collins, 2003; Sjoberg and Schreiner, 2005; Au 2007). Thus, calling for a curriculum of science and its pedagogy which is argument-driven.

Argumentation provides a means for the resolution of certain controversial issues in sciences (Fuller, 1997; Taylor, 1996). Such a practice has been a neglected feature of science classrooms and has provided an erroneous perception about scientific practice as plain, unproblematic, unidirectional and irrefutable (Geddis, 1991). Schwab (1962) has portrayed a clear picture of science class rooms that is even evident in today's time,

"Taught as a nearly unmitigated rhetoric of conclusions in which the current and temporary constructions of scientific knowledge are conveyed as empirical, literal and irrevocable truths"

An argumentative discourse is central to the very nature of sciences and is inbuilt in the character of sciences which are said to be socially constructed knowledge structures (Duschl, 1990; Fuller, 1997; Taylor, 1996; Gregory and Miller, 1998). However, a rhetoric or one-sided argument is to be rejected as it relies upon teacher as the sole constructor and arbiter of the argument rather than invoking students into the practice of argumentation (Driver et al, 2000).

### *Science as a 'Socially Constructed Knowledge'*

It is an extremely flawed premise to think of science as a solitary and an individualised practice. Sciences and scientific knowledge is a socially constructed phenomenon which is more of inter-psychological as compared to intra-psychological. This has been a radical change in the perception and has given way to discursive practices of pursuing and perusing science and argumentation in science as a major pedagogical innovation (Driver et al, 2000). Broadly, a need for re-consideration of a socio-cultural approach to teaching and learning sciences has been largely felt which would empower the learner as an active participant in the processes of science education. Students' ideas, experiments and methods should not be viewed from a traditional and rigid scientific method and hypothesis verification rather could be seen as an act of collecting evidences and reaching their own claims and justifications. Thus, instead of a mere training in some skills and procedures, science education should aim for the larger scientific literacy (Miller & Osborne, 1998). Science is now been treated as a social-knowledge field and can be viewed as a knowledge tree which has different knowledge strands as conceptual turnings which incorporates the diverse views of the world that is being sampled

(Goonatilake, 1998). The cultural and the regional groups scattered around the world have developed their own indigenous domains of knowledge, mode of enquiry and analysis which have been many-a-times ignored and rather muted by the hegemonic systems of knowledge.

### **Ethical Issues in Biological Sciences**

Ethical Issues are regarded as the most contentious area of education as these have a clash of interests, values, beliefs, ethical stance, understanding and implications for the human society. Ethical issues usually arise whenever there is conflict of opinion or interests, or threat to the existence of human species. Since ours is a diversified human society with people from varied backgrounds, culture, religious beliefs and practices, hence ethical issues are bound to arise. The issues are ethical in nature as they cannot be resolved by way of scientific method or experimentation rather require a different mode of inquiry referred to as the ethical mode, which require a firm grounding on the ethical theories. Within Biological Sciences, the areas where ethical issues emerge include the area of biotechnology and conservation policies. Even in our day-to-day life, such as, making our food choices, taking medical decisions, our waste disposal habits etc., do involve some or the other sort of ethical decision making (Minkoff & Baker, 2004). There have always been many debates between the scientists and social philosophers who vie for the inclusion of ethical component in sciences along with some science educators who have tried to integrate this component of ethics in science via socio-scientific-ethical issues (Zeidler et al, 2002; Goldfarb & Pritchard, 2000; etc.). With the discovery and creation of several new technologies, knowledge in the area of ethics becomes even more important, as the right decisions need to be taken regarding the ethically appropriate usage of a particular technology.

#### *Ethical Frameworks for Decision-making*

There are primarily three main ethical frameworks that are being taken recourse to in the present study for understanding and decoding the ethical discourse in the class as well as to analyse the individual arguments made by the students, viz., Virtue ethical framework; Utilitarian/Consequentialist framework; and Deontological framework (Mepham, 2008). *Virtue ethical theory*, propounded by Aristotle (384 B.C to 322 B.C) puts an extended emphasis on the person who performs the actions and makes choices. It relies upon the observance of a good and moral behaviour that can be acquired by choosing right action, by renouncing the desire for material objects and leading a moral and virtuous life. The *Utilitarian/Consequentialist theory* founded by Jeremy Bentham (1748-1832) gives more attention to the consequences and rewards of a particular action which need to be for the greater benefit of the people. The *deontological theory* on the other hand stresses on the observance of one's duty toward oneself as well as toward others, and the ends do not justify the means. One of the greatest proponents of this theory is Sir Immanuel Kant (1724-1804) who had named it as 'Kant's Categorical Imperative' of which two main principles are- (a) Universalisability, such that an action which is taken up can be converted into a maxim that is universally applicable (Statement: "Act only on that maxim whereby thou canst at the same time will that it should become a universal law"); (b) the second principle is based upon the need to respect and treat humanity, both as in your person and the other, not as a means only but an end in themselves (Kay, 1997).

### **Research Method**

#### *Sample*

The sample for the present study comprised of two high school teachers (Case A1 & Case B1) teaching at K-12 level and their pupil, and one teacher (Case A2) teaching undergraduate courses related to Biological Sciences and her students. All the samples are taken from the schools and colleges in the Delhi region of the Indian subcontinent.

#### *Data Collection*

A case study design has been adopted for the present study involving a multi-method approach (Swanborn, 2010). The sites for data collection were mainly the science class rooms where active conversations took place between the teacher and the students. Sometimes students' conversations also became interesting to note down especially in the absence of their teachers but with the help of a moderator, whose role was being played by the researcher. The topics chosen for collecting data in the form of teacher-student conversations and students' arguments were mainly the socio-scientific-ethical issues with a special focus on the ethical dimension and relevant with their course content. The data collected was usually in the form of field notes and video recordings of classroom observations and focussed group discussions with students at undergraduate level.

### Data Analysis

Since the focus of the present study is the classroom interaction between the teacher and the students as well as amongst students, therefore classroom discourse became the major element of analysis. The classroom discourse analysis for the present study is unlike the other studies in languages where it takes into account technical syntax, language structure and form of the classroom conversations rather is more focussed on the content of the discourse. The content of the discourse has been analysed on four planes, viz., ethical, social-contextual, interactional and personal agency of the teacher (Rymes, 2008). The arguments arising from both teacher led class room discussions as well as moderator led students' discussions were noted down and video-recorded wherever possible. These were then subjected to argument analysis using the Toulmin's Model of Argumentation (Toulmin, 1958, 2003)

*Toulmin's Method of Argument Analysis:* Since the major form of data collected during the present study was qualitative and descriptive in nature and consisted mainly of arguments in textual or oral form, therefore argument analysis seemed to be the viable means for analysis. Toulmin's model of argument analysis is one such method developed by Stephen Toulmin (1958) which helps in analysing the quality of any argument by breaking it into six different components viz., data, claim, warrant, backing, qualifier and rebuttal. (see fig.1)

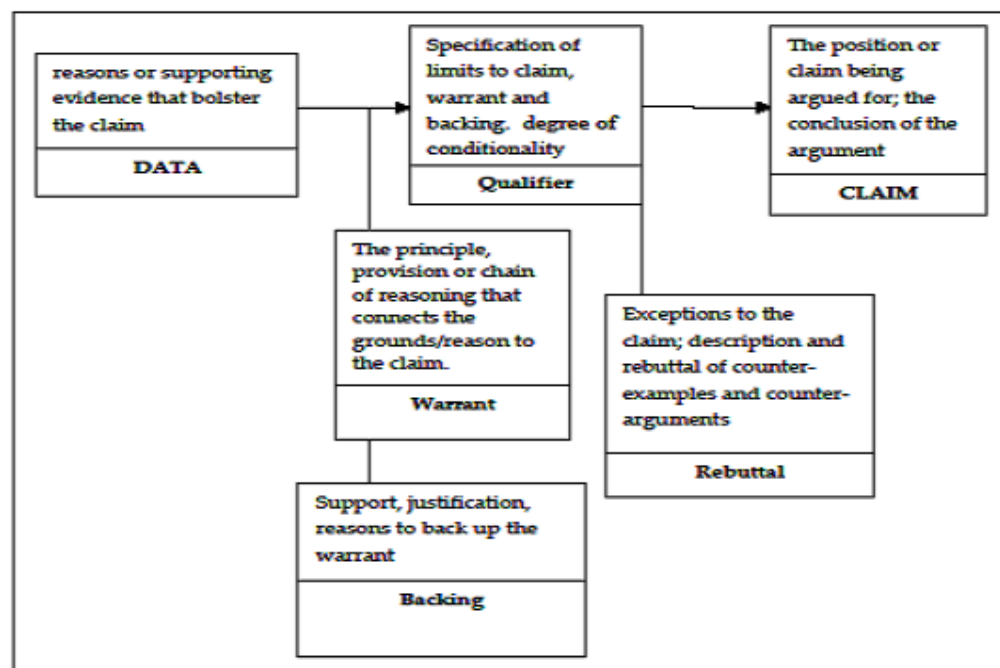


Figure 1. Toulmin's Model of Argumentation (Toulmin, 1958)

The 'claim' here presents the main thesis or the controlling idea, whereas the 'data' provides the support for the claim by providing certain evidences and grounds for its occurrence. 'Warrants' are the accepted beliefs or assumptions that are often implicit and mainly support the data in one form or the other. 'Backing' helps in providing support to the warrant and usually is normative in nature, such as universal theories, rights, rules and regulations, etc. 'Qualifiers' determine the probability of truthfulness of the claim and the incidents when the claim holds true. Lastly, 'rebuttals' are the instances where the claim does not hold true and help in making a stronger argument. It is generally said that arguments that have all these six components inherent in them are the strongest arguments and qualitatively richer to those where any of these components goes missing. The rubric for analysis based on Toulmin's model developed by Erduran et al (2004) has been adapted for the analysis of teachers' arguments in the present study (see table 1).

**Table 1.** Rubric for assessing the quality of Argumentation (Adapted from Erduran et al, p.928)

LEVELS OF ARGUMENT	QUALITY OF ARGUMENT
<b>LEVEL 1</b>	Argument consisting of a simple claim based on a personal belief without any evidence/data/warrant/backing/rebuttal
<b>LEVEL 2</b>	Argument consisting of a claim supported with data/evidence/backing which provides a valid reason for the claim but having no rebuttal
<b>LEVEL 3</b>	Argument with a series of claims or counter claims with data/warrant/backing that support the claim but having only a weakly identifiable rebuttal which indicate a pre-ponderance toward the validity of claim
<b>LEVEL 4</b>	Argument having several claims and counter-claims supported with evidences and data and having a clear rebuttal which refutes the claim. Such an argument can also indicate a state of ethical dilemma
<b>LEVEL 5</b>	An elaborated argument with more than one rebuttal indicating a true engagement with the argument and approximation to a consensus or truth (leading toward ethical decision-making)

### **Results and Findings: Evidences from the Field**

Some excerpts from classroom discussions and focussed group sessions around ethical issues can be presented as follows and they have been analysed based on the theoretical framework developed for the present study.

**EXCERPT-1****Case A1; Topic: Amniocentesis; Level: K-12**

Teacher: Why should we be worried about female foeticide?

Student1: Depression in the sex-ratio.

Teacher: So What?

Student2: More risk to female population, balance in society is also affected.

Teacher: what will happen when this population reaches reproductive stage?

Student3: This could lead to a rise in the incidents of STDs (Sexually Transmitted Diseases).

Teacher: Is it a sign of a healthy society?

Student 4: No.

From the above classroom discussion, it is evident that both teacher and students are taking turns to share and respond to the questions that are most of the times initiated from the teacher's side. Students give their responses as one-liners and very brief without any further elaboration either by the learner or by the teacher. Moreover, the topic is being deviated from its focus which was earlier on Amniocentesis and later on got shifted to sexually transmitted diseases (STDs) which again indicates that these issues of ethical concern are being sidelined or averted by the teacher. Not a single mention about the issues of gender inequality, prevalence of patriarchy in Indian society and the violation of basic human rights and the right to life were discussed in the class room. The role of teacher as an 'agency' is noteworthy here, as she could have taken an initiative to raise certain issues on social inequality, prevailing gender biases, or patriarchy. But, astonishingly, no such issues were raised that were so much pertinent for an issue like sex-determination via amniocentesis and ensuing female foeticide. This can be attributed to different reasons such as the lack of curricular focus on such issues, as is evident from the K-12 textbook practiced in schools where no ethical issues are being raised with respect to amniocentesis, other could be paucity of time and lack of teacher's training and orientation with respect to ethical issues.

**EXCERPT-2****Case A1; Topic: GM Crops; Level: K12**

Teacher: What do we mean by the great cotton rush and to whose benefit it might be?

Student1: To the farmers who are growing cotton.

Teacher: Earlier the cotton yield was drastically affected and destroyed by an insect pest called as 'Boll worm' that infested the cotton fields. What solution was proposed by the scientists?

Students2: Use of Biotechnology to develop pest-resistant crop-plants.

Teacher: It is a win-win situation for farmers as once they buy Bt-cotton seeds from the market, later they can grow their own Bt-seeds. Now, is it possible for a farmer who does not have any knowledge about Bt-cotton to grow his own Bt-seeds?

Student3: Yes, the farmers can grow their own Bt-seeds with each yield by the process of self-pollination.

Teacher: Why Bt-cotton and not natural variety?

Student4: This is because it reduces the cost of production by lesser to negligible use of pesticides.

Teacher: In Orissa, many farmers were committing suicide as they did not have money to invest in pesticides and fertilisers, therefore the only option left to them was Bt.

The above class room discourse is also from the same teacher's class room and follows a similar pattern of turn-taking between teacher and the students. Again, most of the questions are coming from the teacher's side with students responding to them. The kinds of arguments given by the teacher appear to be pro-technology such as, "It is a win-win situation for farmers as once they buy Bt-cotton seeds from the market, later they can grow their own Bt-seeds". The teacher is very much assured that Bt-seeds are for the good and increase the crop productivity as well as offer pest resistance against boll worm. The students also comply with their teacher and adopt the teacher's stance in framing their arguments in favour of Bt-Crops. As is evident, no ethical issues were raised during the discussion such as, the issue of food safety, health risks associated with Bt-crops, horizontal gene transfer and dilution of species, etc. The explanations offered by the teacher were also minimally stated by restricting them to the content given in the text-book. The arguments given both by the teacher as well as by the students in favour of Bt-crops, such as Bt-seeds can be reused, and that they require negligible amount of pesticides need further confirmation with evidences. As some reports have proved that Bt-seeds obtained from the harvested Bt-crop are infertile as also Bt-crops require some amount of pesticides. Thus, the information transferred and received by the students is only partially correct as there are so many ethical concerns surrounding GM crops that remain unaddressed in the discussion. There was no real argumentation happening in the class, and it was more of a question-answer session with little disagreement or dissonance which is a hallmark of discussion on such contentious issues.

### EXCERPT-3

#### Case B1; Topic: GMOs; Level: K-12

T: Should this indiscriminate use of genetically engineered organisms be continued unregulated? Do we know the long-term impact of such transgenic organisms on our ecosystem and the flora and fauna?

St1, 2, 3, 4: No

T: So how do we curtail the indiscriminate use of genetically modified transgenic organisms?

[Teacher asked the students to underline at this point in the text-book about the role of organisations such as GEAC or Genetic Engineering Accreditation Committee, refer to p. 213, section 12.4, 3<sup>rd</sup> para]

T: Should there be organisations like GEAC?

St5: Yes, there should be.

St6: But, research is also important.

T: Such organisations help in testing the validity of a particular research as well as its possible impact on society and environment.

The excerpt-3 is part of the class room discussion between another K-12 Biology teacher and her students. The topic for the class in this case is genetically modified organisms (GMOs). Here the teacher is the one who is doing most of the talking in the class, with minimal participation from students' side. The two ethical arguments being raised in this case by the teacher were, "Should this indiscriminate use of genetically engineered organisms be continued unregulated? Do we know the long-term impact of such transgenic organisms on our ecosystem and the flora and fauna?" of which the first argument is normative in nature and emphasises upon some codified rules and regulations for introducing GMOs into the environment. The other argument raised by the teacher is consequential in nature and assesses the long-term impact of GMOs on the ecosystem. These arguments were just mentioned by the teacher and not discussed in depth by taking into consideration students' opinions. However, no ethical argument was being raised from the students' side which again establishes the authority of the teacher in the classroom as also lack of awareness about such issues amongst the students.

## EXCERPT-4

**Case A2; Topic: GMOs; Level: K-12+3**

T: Till now we have been studying about some of the benefits of these Biotechnological techniques, such as transformation. But, *do you think that there could be certain drawbacks or some safety concerns attached to their use? Have you heard about GMOs? (Consequentialist) (KArg)*

S1: These are the genetically modified organisms or crops.

T: So, crops that are edible, they are genetically modified, which means that a foreign gene has been added to them, *do you think that this foreign gene when ingested by us could cause any side-effect on a person's health? (consequentialist)*

S2: *it can lead to a mutation.*

T: *till now we ourselves are not clear that which kind of DNA material will produce what kind of effect on different individuals. (Consequentialist)*

S3: *it can also interrupt the food chain.*

T: *how can we be so sure that if a transgene is entering our body, it will not cause any altered reaction? (consequentialist)* It is quite possible as it is something new which has not been created by nature. Rather, it has been created by human being.

S4: Each one of us is having a different set of genetic repertoire and thus, *the effect of a particular transgene can be varied across different sets of population. One may have a positive effect and the other may have a negative.*

T: Yes... any other argument?

S5: *If while making a transgenic bacteria containing marker genes which are usually antibiotic resistance genes, then this could lead to the production and selection of some antibiotic-resistant bacterial strains or super-bugs. (consequentialist)*

T: *yes, and that will mean that they will have resistance toward a broad spectrum of antibiotics, on which even a very low to a very high dosages of antibiotics will have no effect and the day will not be far, when repeated dosages of these antibiotics will confer more and more resistance to these bacteria as in them the plasmid DNA will interact with nuclear DNA for developing more mutations and resistance. (Consequentialist).* That means we should be very sure while making different strains of bacteria, so that they are not left freely in the society or the environment. Otherwise, the day is not far, where instead of providing us with some help, these bacteria could be a cause for a major threat. The most devastating of which would be biological warfare. Any other caution that should be taken care of?

S6: *in the case of edible vaccines, there is a difference between the plant system and an animal system, and no one can predict what kind of consequences can be there in the long run. (Consequentialist)*

The above class room discourse is from an undergraduate science class room. The topic chosen for the class was Genetically Modified Organisms (GMOs). Here, both the teacher as well as students share equal chances of participation in the discussion. Unlike the class room discussions at K-12 level, the discussion in this undergraduate science class room is more elaborative with logical and evidential arguments. Many ethical arguments were being raised simultaneously by the teacher and the students (marked with italics) resulting in an ethical discourse. Most of the ethical arguments posed by the teacher as well as students relate to the unpredictability of the outcomes associated with the genetically modified organisms, mostly their unforeseen impact on the human health and environment. Since the number of students in this particular undergraduate class room were lesser as compared to the K-12 class room, which could be one of the reasons that favoured elaborative student and teacher arguments and dialogue. Another reason could be familiarity with the content and a well built knowledge repertoire of both the teacher and the students with respect to GMOs. At K-12 level, GMOs were just being introduced for the first time. The teacher's agency also plays a significant role here, as here the teacher herself is aware about the ethical issues associated with this Biotechnology



and is very much interested in addressing them in her classroom, which further help in building the interest level of the students and motivated them to respond and share their opinions in the class room discussion.

#### EXCERPT-5

##### Moderator-driven Discussion on 'GM Technology' (Level: K-12+3)

--- What is your general take on GM crops and GM technology per se?

S1: although we have studied about GM crops, but in the long run we do not know what will be their impact on human health.

S2: But, these crops are certainly known to increase the production level.

S3: We have inserted a foreign gene into the plant which can lead to any kind of health hazard or an adverse impact on the environment.

S4: Since Bt-cotton was not edible but Bt-Brinjal is edible, due to which a lot of controversies have been attached to it.

--- Looking at the recent researches and recent reports, what do you think is the future of Bt-Cotton in India? Has it been a success or a failure?

S4,5,6,7: It has been a failure.

--- Why do you think so?

S5: The Bt-gene could escape in the environment.

S6: the soil fertility also got decreased.

S7: Increase in farmers' suicidal tendency because of loss of crop.

S2: Some regulatory bodies can be set up that monitor the quality and field trials of GM crops.

S4: The suppliers of these GM seeds or crops should ensure the farmer or the consumer of the safety of the crop.

S5: the crops should not be produced in bulk but in a limited quantity so as to monitor their impact on environment and human health.

S11: what about GM- rice or golden-rice that are said to be a precursor of beta-carotene and are so much useful for feeding the malnourished population?

The above class room discourse revolves around the issue of Bt crops and is a moderator driven discussion, which means that it is conducted in the absence of the teacher. This is an important contextual feature here, as many-a-times the students may not feel free to express their opinion in the presence of their teacher. A great number of students participated in the discussion as is evident from the number of student participants. One important finding that emerged from the discussion was that although students raised a number of ethical arguments against GM crops, but only a few were able to base their arguments on valid evidences or research reports. However, many of them were able to provide scientifically logical arguments to support their point. Some suggestions that came out from this discussion were truly ingenious, such as,

*"The suppliers of these GM seeds or crops should ensure the farmer or the consumer of the safety of the crop."*

*"The crops should not be produced in bulk but in a limited quantity so as to monitor their impact on environment and human health."*

Thus, although a moderator-driven class room discussion could bring out many students' beliefs and opinions on the issue of GM crops, but the quality of the arguments need to be improved. As per the Toulmin's model of argumentation (1958), an argument is considered to be 'good', if it possesses the six components, viz., evidence, claim, backing, warrant, rebuttal and qualifier. But, in the present case most of the student arguments were purely claims without any evidence or backing. Therefore, such arguments are considered to be weak arguments.

## EXCERPT-6

**Moderator-driven Discussion on 'Gene Therapy' (Level: K-12+3)**

---- Is doing gene therapy a good idea to begin with?

S2: I think that if there is an alternative treatment available then one should go for it first.

---- Do you think that this gene therapy is only for a specific set of diseases or it can be applied to all sorts of disorders?

S3: In diseases where some gene disorders are involved, in those genes therapy can be possible. And it specifically targets that particular gene.

---- But, just now we discussed that this gene therapy right now is not that specific and can even hamper the functioning of the non-target genes.

S4: In that case, some specific procedures such as in-vitro insertion of genes can be used.

S3: Using some vectors, as they add to the specificity of gene inserts.

---- How would you rate chemotherapy vs. gene therapy, which one is safe?

S3: Till date what we have been using is chemotherapy, gene therapy has not come into practice yet but yes we are trying. I would rate chemotherapy as more beneficial than gene therapy.

S5: But, *gene therapy would be a very expensive procedure to begin with and not everyone would be able to afford it.*

S6: I think there is no problem; rather *the treatment is more effective and lasting in the case of gene therapy.*

---- Then, what about the gene enhancement techniques, wherein genes are artificially introduced to enhance or improve upon certain behavioural traits such as intelligence, athletic abilities, etc, what is the whole issue about genetically engineered babies?

S7: Insertion of certain genes which are of interest to the parents.

---- But, how fair is that?

S3: It is not natural.

S4: *I think this way we are fiddling with the nature's own process of creation. Such procedures can also be deterring to the evolution of species which is a natural process.*

S8: *Such kind of children (genetically engineered) may not lead a normal life as they will have an early expression of certain genes that a normally grown child will not have which would again act as a social barrier for that particular child, and he/she may even be excluded from others of same age group.*

---- What kind of social position will such a child hold in the society?

S4: *For every achievement that the child makes in his life, it would always be his genes which will receive the credit and not his own hard work or capabilities, this way it could also lead to declining self worth of that child.*

S3: But, we still don't know about the statistics as to how many diseases have been really cured successfully using gene therapy. But, wherever chemotherapy fails, in those cases we can try gene therapy, as we have seen that in case of stem cell therapy which has been successful in treating some cancer in AIIMS.

The above class room discourse is a moderator-driven discourse on the topic 'gene therapy'. Gene therapy is one topic that is beset with so many ethical issues pertaining to both somatic as well as germ-line gene therapy. A number of ethical issues were raised by the students (indicated in italics) and in this case their arguments sounded more coherent and logical. Also, the arguments are based on evidences either from daily life or simply drawing on the theoretical explanation to reach a particular claim. Majorly the ethical issues associated with 'gene therapy' were derived from misuse of gene therapy in the creation of genetically engineered babies, wherein a selected repertoire of genes is

incorporated in the fetus. A number of students were able to imagine the consequences of such a technology such as estranged relationships, social acceptance or exclusion of the child, decreased self-worth and self-esteem of such a genetically engineered child, etc. The factors that can be attributed to such an informed class room discussion could be many, like, students' interest in the topic, heightened levels of awareness about this topic and associated ethical issues, as well as teacher's effectiveness in teaching this particular topic which is reflected in students' responses.

## Discussion

The evidences and data collected from different science class rooms at two different levels is indicative of the fact that ethical discourse however negligible (especially at K-12 level) is a feature of some science class rooms in India. Although implicit, ethical arguments are being raised both by the teachers and the students knowingly or unknowingly in the class room. These arguments are primarily based on the three main ethical theories, viz., virtue ethical theory, utilitarian (or consequentialist) theory and deontological theory. However, a marked difference can be observed in the nature and quality of the ethical arguments at the K-12 and undergraduate level. The arguments generated both by the teachers and the students at K-12 level are too concise and brief, with just a mention about some of the ethical issues and that too in a very generic sense (refer to table-2 & table-4).

**Table 2.** Analysis of Students' Arguments at K-12 Level (Based on Toulmin's Model of argumentation, 1958)

Student No.	Data	Claim	Warrant	Backing	Qualifier	Rebuttal	Level
1.		Depression in sex-ratio					1
2.	More risk to female population	Balance in society is affected					2
3.		Rise in the incidents of STDs.					1
4.		Use of Biotechnology to develop pest-resistant plants					1
5.		Farmers can grow their own Bt-seeds with each yield by the process of self-pollination.					1
6.		It (GM crops) reduces the cost of production by lesser to negligible use of pesticides					1

**Table 4.** Analysis of Teachers' Arguments at K-12 Level (Based on Toulmin's Model of Argumentation, 1958)

Teacher Code	Data	Claim	Warrant	Backing	Qualifier	Rebuttal	Level
A1	Earlier the cotton yield was drastically affected and destroyed by an insect pest called as 'Boll worm' that infested the cotton fields.	It is a win-win situation for farmers	once they buy Bt-cotton seeds from the market, later they can grow their own Bt-seeds	Utilitarian			2
B1		Should this indiscriminate use of genetically engineered organisms be continued unregulated? Do we know the long-term impact of such transgenic organisms on our ecosystem and the flora and fauna?					1

On the other hand, the ethical arguments generated at the undergraduate level (both teacher driven and moderator driven) happen to be much more elaborative, conceptually driven and based on evidences (see table-3 & table-5).

**Table 3.** Analysis of Students' Arguments at Undergraduate level (Based on Toulmin's Model of Argumentation, 1958)

Student No.	Data	Claim	Warrant	Backing	Qualifier	Rebuttal	Level
1.	Each one of us is having a different set of genetic repertoire	The effect of a particular transgene be varied across different sets of population.	One may have a positive effect			the other may have a negative	3

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2.	marker genes which are usually antibiotic resistance genes	this could lead to the production and selection of some antibiotic-resistant bacterial strains or super-bugs.	2
3.		in the long run we do not know what will be their (GM crops) impact on human health.	1
4.		These crops are certainly known to increase the production level.	1
5.		The Bt-gene could escape in the environment.	1
6.		The soil fertility also got decreased.	1
7.	GM- rice or golden-rice that are said to be a precursor of beta-carotene	and are so much useful for feeding the malnourished population.	2
8.	Till date what we have been using is chemotherapy	I would rate chemotherapy as more beneficial than gene therapy	2
9.	gene therapy would be a very expensive procedure to begin with	not everyone would be able to afford it.	2

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10.		The treatment is more effective and lasting in the case of gene therapy.	1	
11.	Such procedures can also be deterring to the evolution of species which is a natural process.	I think this way we are fiddling with the nature's own process of creation.	2	
12.	they will have an early expression of certain genes that a normally grown child will not have	Such kind of children (genetically engineered) may not lead a normal life	Which would again act as a social barrier for that particular child, and he/she may even be excluded from others of same age group.	2
13.	For every achievement that the child makes in his life, it would always be his genes which will receive the credit and not his own hard work or capabilities	it could also lead to declining self worth of that child.	2	

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**Table 5:** Analysis of Teachers' Arguments at Undergraduate Level (Based on Toulmin's Model of Argumentation, 1958)

Teacher Code	Data	Claim	Warrant	Backing	Qualifier	Rebuttal	Level
A2	crops that are edible, they are genetically modified, which means that a foreign gene has been added to them,  transgenic bacteria containing marker genes which are usually antibiotic resistance genes, then this could lead to the production and selection of some antibiotic-resistant bacterial strains or super-bugs	there could be certain drawbacks or some safety concerns attached to their use	till now we ourselves are not clear that which kind of DNA material will produce what kind of effect on different individuals.			Some of the benefits of these Biotechnological techniques, such as transformation.	3

This can be attributed to many reasons such as deeper subject matter knowledge of both teacher and students at the undergraduate level, heightened awareness levels with regard to the ethical issues associated with emerging technologies, greater sensitivity toward these issues, and teacher efficacy in transacting the topic which leads to greater students' participation. The class room discourse pertaining to ethical issues can be dissected on four different planes, viz., ethical, socio-political context, interactional context and personal agency of the teacher.

*Ethical Context:* As is evident from the classroom excerpts at K-12 and undergraduate level, the teachers are able to raise some ethical arguments in the classroom during the transaction of ethical issues. However, a marked difference exists in the level of argumentation at both the levels, viz., K-12

and Undergraduate level, which is evident from the number and variety of arguments that teachers are able to raise at undergraduate level. Teachers' arguments at K-12 level are mostly utilitarian in nature, whereas teacher's arguments at Undergraduate level are much more elaborated, substantiated with evidences and examples and point toward the major ethical concerns that underlie the use and application of any technology. Thus, teachers' arguments at K-12 level can be taken more as beliefs whereas teachers' arguments at undergraduate level appear to be more reasoned & rational. The students at K-12 level usually adopt their teacher's stance and comply with them; on the other hand, students at undergraduate level are able to generate their own logical arguments for any technology at hand. This proves that undergraduate students are more informed about the ethical issues as compared to K-12 students. This difference can be attributed to a number of factors such as, better grasp of the subject and the principles of biotechnology, exposure to technology in the form of practicals, experiments, research, etc., ability to take own stance and frame an argument although at times dilemmatic, etc.

*Social Context:* the school or institution environment, the curriculum structure, the syllabi and co-curricular activities, the resources available, the time frame, all of these constitute the social context of the class room interaction. Class room discussions narrated in the present study have been derived from the topic specific transaction based on some of the ethical issues in Biology and Biotechnology. As already discussed, there is a difference in the class room discourse recorded at K-12 level and that at undergraduate level. The social and political contextual factors that could be responsible for it can include syllabus and time constraint at K-12 level which is not so at undergraduate level. Another important contextual factor worth mentioning at this point is the teacher's autonomy at undergraduate level with respect to content selection and mode of its delivery which is not permitted at K-12 level, where the teacher is bound by the rules of the respective institution and the text-book which is prescribed by the state Government. Undergraduate teachers also have a luxury of time as compared to their school counterparts which is evident from the length of teaching periods at K-12 (which stretches from 25 mins-35mins) and undergraduate level (from 50mins-approx. 2hrs). Another social contextual factor that could have influenced the class room discussion is the exposure to print and visual media besides the course content such as magazines, journals, web-search, documentaries on some such contemporary technologies by the undergraduate students which is not so with the K-12 students.

*Interactional Context:* this particular component deals with the inter-relationships shared between teacher and her students and even amongst the students. A 'good' inter-personal relationship can promote a healthy class room discussion which is rewarding both cognitively and psychologically. In the class room discussions narrated in the present study, the first three class room discussions are more limited in terms of students' participation as compared with the later ones. Rather the initial class room discussions can be taken as more of an inquiry based processes following an I-R-E (Initiation-Response-Evaluation) pattern rather than fostering a deeper engagement with the issue. In the class room discussions at undergraduate level, a dialogical relationship can be observed where there are no set definitive answers rather a process of consensus building. The students share their ideas and opinions freely with their teacher without any fear which is not the feature at K-12 level. Here again, the role of teacher is pertinent in establishing 'good' inter-personal relationships. Since teachers at K-12 level exercise a greater authority over students, therefore the class room environment is not as open as is required to transact these ethical issues. At undergraduate level, the teachers appear to be friendlier with their learners and hence share a bond with them which is helpful in having detailed discussions and debates.

*Personal Agency:* The role of personal agency of the teacher cannot be neglected in the discussion of these topics. As teacher is the one who selects the content to be taught to her students, designs the



strategy to transact it (lesson planning), and assesses the learners on the learning outcome of the lesson. The subject matter knowledge of the teacher with respect to the topic at hand is of extreme importance here, as only then valid and logical arguments can be generated. Besides, since the focus here lies on ethical issues, therefore, a working knowledge in the area of ethics is also expected of the teachers to make the teaching of ethical issues more effective. The decision making with respect to teaching of ethical issues is required which in majority of the cases is regulated by official regulatory framework (ORF). However, in the class room discussions mentioned above, an effort has been made on the part of the teacher to bring to fore some of the implicit ethical issues. But, it is evident from the length of these discussions, that at the K-12 level the teachers are somewhat reticent and do not open up much with these issues as compared to their counterparts at undergraduate level. K-12 teachers do not feel confident enough to hold a discussion on the topics having an ethical relevance which can be ascertained from their treatment of the ethical issues as any other topic as well as lack of sensitivity attached to them.

## **Conclusion**

The present study gives the inside view of biology class rooms in engaging us with the classroom dynamics surrounding some of the ethical issues within Biological Sciences. One of the major bottlenecks to effective science teaching is that teachers are teaching science just like any other subject. Moreover, within science there are so many variations with respect to its allied disciplines such as Biology in the present case, within which are different topics and areas, each of which need to be taken up differently. The teachers are practicing the age old conventional methods of teaching with no innovation or diversion from the conventional methods. Argumentation in sciences is well known as a teaching learning pedagogy that sharpens the analytical and problem-solving skills of the learners. In order to study the argumentative practices, some science class rooms were observed and analysed with respect to the quality of arguments generated. The topic chosen for the study was ethical issues in Biology and Biotechnology, as they are highly contentious and can only be tackled via argumentation or debate.

The findings indicate that there is a vast difference in the quality of ethical arguments generated at K-12 and undergraduate level. The arguments generated both by the teacher and the students at undergraduate level are logical and well supported with evidences unlike those at K-12 level that are merely claims and beliefs which are mostly shared by the teacher and very few students. Most of the students at undergraduate level share their opinions with their teacher and even come out with some suggestions to resolve the ethical issues associated with a particular technology. This is indicative of the fact that the social as well as interactional context at undergraduate level is favourable with respect to discussion and engagement with ethical issues in an argumentative manner. Thinking in terms of Freire's ideas (*Pedagogy of the Oppressed*, 1972), education as a whole is creating passive learners who take the knowledge as a 'given' and do not question its very existence. The social as well as interactional context especially at K-12 level need to be more flexible and autonomous in order to discuss and deliberate on ethical issues. The pre-service teacher education programmes need to build a holistic approach to dealing with these issues in the class room and provide orientation and training to the teachers in this regard. The curriculum and assessment system also needs to give space and consideration to ethical issues in biological sciences as only then they will be taken up seriously in the classroom. The narratives from undergraduate science class rooms presented in the study provide evidences that are counter-intuitive, where the students are questioning the very existence and application of a technology such as GMOs or Gene Therapy. This indicates a difference in the intent and approach of dealing with the ethical issues in the classroom. Besides curriculum, teacher's role is significant in this regard, as a teacher who is motivated and sensitive towards these issues is likely to take them up in the classroom in an effective manner whether they appear in the curricular objectives or not. Hence another factor influencing the argumentation over ethical issues in the classroom is teacher's motivation and autonomy.

## Educational Implications

The present study has been conducted with a focus on teachers at K-12 and undergraduate level; therefore the implications are also majorly drawn for the teacher education and development. The study especially has implications for enhancing the knowledge component of teachers which deals with transaction of ethical issues in the classroom which is a sub-component of their pedagogical content knowledge (PCK). Pedagogical content knowledge (PCK) is a component of teacher's knowledge base at the intersection of pedagogical knowledge and content knowledge. It includes the most regularly taught topics, the most useful forms of its representation, most powerful analogies, examples, demonstrations, etc. (Shulman, 1986).

Foremost, is the teachers' knowledge of subject matter of ethical issues that plays an important role in their effective transaction. It has been found that teachers at undergraduate level have a better grasp of the subject content of ethical issues as compared to their counterparts at K-12 level and are thus, more effective in their teaching of ethical issues. Second, is the knowledge of argumentation, which also depends on the subject content knowledge as well as some understanding of ethics. Here, it was found that again undergraduate teachers are able to formulate well structured and rational arguments (as depicted in table 4 & 5) as compared to K-12 teachers. This could be due to heightened awareness levels and sensitivity to ethical issues among undergraduate teachers as compared to K-12 teachers. Another implication of the study is the role and impact of social context on classroom environment which could either facilitate or hinder an authentic ethical understanding with respect to these issues. since undergraduate classroom environment provides more freedom and liberty for student expression, a similar kind of environment need to be created in K-12 classroom rather than perpetuating fear, it should foster confidence and decision-making abilities amongst students. Finally, the teacher's personal motivation, sensitivity, feelings and emotions also play a key role in transacting ethical issues in the classroom. Thus, the development of this affective side of teachers' personality is as much important as the cognitive or intellectual side for an appropriate addressal of ethical issues in the classroom.

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